DISCOVERY

57(308), August, 2021

To Cite:
Jaishi PP, Budhathoki S. Assessing Drivers and Dynamics of Land Use Land Cover Change in Churia Region of Makwanpur District Using GIS and Remote Sensing. *Discovery*, 2021, 57(308), 608-620

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Peer-Review History
Received: 26 May 2021
Reviewed & Revised: 27/May/2021 to 09/July/2021
Accepted: 12 July 2021
Published: August 2021

Peer-Review Model
External peer-review was done through double-blind method.

DISCOVERY
SCIENTIFIC SOCIETY

Assessing Drivers and Dynamics of Land Use Land Cover Change in Churia Region of Makwanpur District Using GIS and Remote Sensing

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ABSTRACT

Land use and land cover, a dynamic process, has become a key component of current natural resource management and environmental monitoring systems. Drivers and Dynamics of LULC in the Churia region were assessed with an integrated approach using remote sensing and GIS techniques together with socioeconomic data for land use land cover change detection. Landsat TM of 1995 and Landsat OLI/TIRS of 2018 satellite imageries were used for land use land cover change detection between 1995 and 2018 in the Churia region of Makawanpur district of Nepal. The study's goal was to look into land use and land cover (LULC) change detection between 1995 and 2018, and to examine the dynamics and the driving forces of these changes, and also to analyze the rate of LULC change. Key informant survey, training sample collection, Satellite images download, and direct observation was done for the collection data. Image processing was done through supervised classification to prepare land use maps using the Maximum Likelihood algorithm. Image classification was carried by emphasizing five main categories. Data of different LULC classes obtained from the field study (GPS location) were used as training samples for supervised classification. Ground verification was done during the field visit and through Google Earth images. The study reveals an astonishing net decrease in 'forest cover' 'cultivated land' and 'water' whereas a concomitant increase in 'built-up area 'and 'sand/gravel'. The forest cover of 99,254.19 ha in 1995 decreased at a rate of 0.45 percent per year to 89,449.49 ha in 2018. Whereas cultivated land of 24,891.66 ha in 1995 decreased at a rate of 0.52 percent to 22,098.06 ha in 2018. Similarly, the built-up area of 4,938.76 ha in 1995 increased at a rate of 4.91 percent to 14,859.69 ha in 2018, sand/gravel of 7,662.86 ha in 1995 increased at a rate of 1.58 percent to 10989.59 ha. Forest cover is declining at the cost of cultivated land, while cultivated land is declining at the cost of built-up area. Different socioeconomic factors were associated with the forest cover decreased such as an increase in cultivated land, settlement, infrastructure development, riverbank cutting, and erosion.

Keywords: Churia, GIS, Landsat, Land use Land cover, Remote sensing, Supervised classification

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1. INTRODUCTION

Land use and land cover (LULC) is considered as one of the most important components of the terrestrial environment system (Lin et al., 2009). The effects of human activities on the global environment are mirrored in the dynamics of LULC (Houghton et al., 1999; Schneider and Eugster, 2005).The LULC influences the distribution and dynamics of terrestrial biodiversity, ecological structure, and function, leading to the loss of habitat and entire ecosystems (Pettorelli et al., 2005). The LULC dynamically modifies the availability of different important resources, including vegetation, soil, water, and others (Bruijnzeel et al., 2004). Due to different socio-economic activities and natural occurrences, the earth's surface is undergoing fast (LULC) changes (Cheruto. 2016).

The impact of land cover change is likely more significant than climate change since it changes all the biophysical components of ecosystems (Chapin et al., 2000). Understanding the dynamics and predicting the patterns and trend of changes in a natural landscape and associated ecosystems at local, regional, and global scales, as well as providing evidence-based support to improve land management policies and practices, requires continuous study and monitoring of LULC changes (Lu et al., 2004). The study of LULC provides information about the status of natural resources and helps in monitoring, modeling, and environmental change detection (Krishna et al., 2001).

LULC cover changes may be grouped in two categories: conversion and modification. Conversion is the process of converting from one cover or use type to another, whereas modification is the act of maintaining the broad cover or use type in place despite changes in its features (Baulies and Szejwach, 1998). The driving forces of soil degradation processes on tropical hill slopes are frequently linked to land cover conversion. To sustain rising populations, natural forests have been transformed to agricultural land, resulting in significant changes in soil physical properties such as an increase in bulk density, destruction of soil structure, and a decrease in organic carbon content (Matson and Vitousek, 1987).

Various methods can be used in the collection, analysis, and presentation of research data, but the use of Geographic information systems (GIS) and Remote Sensing (RS) technologies can greatly facilitate the process (Gautam, 2007). GIS and Remote Sensing are now providing an efficient tool for advanced ecosystem management. Remote sensing data allows for more comprehensive studies of earth-system function, patterning, and change through time at local, regional, and global scales. Such data provide a crucial link between rigorous, localized ecological study and regional, national, and international biological diversity protection and management (Wilkie and Finn, 1996). Remote sensing, in conjunction with GIS and GPS, supports in the maintenance of up-to-date of land-use dynamics and information for sound planning and cost-effective decision-making (Rickets, 1992). For this purpose, image processing is done in GIS with supervised and non-supervised image classification for land use mapping (Otieno and Anyah, 2012; Ghimire, 2017). In Nepal, Satellite remote sensing data have been used for the past two decades in specific areas and it's significance is still increasing (Sharma, 2002). Change information about the Earth’s surface is becoming more and more important in the monitoring of the local, regional and global environment.

Nepal is divided into five physiographic regions, High Himalaya, High Mountain, Middle Mountain, Siwaliks /Churia, and Terai (LRMP, 1986). Churia is a bit of a hilly region stretching from East to West in the entire length of the southern part of Nepal. This region is ecologically diverse, and it provides a variety of ecological services to the area downstream, it has a direct influence on the quality of the environment. However, the Churia Hills are structurally weak (Khanal, 1989) since this area is the most newest Mountain range in the Himalayas and has a high potential of erosion hazard. This study is specially designed to explain the changes in the magnitude of various land uses the behavior of transformation between land use, land cover, and the severe transformed areas within the Churia region of Makawanpur district.

Rainfall falls more frequently and with greater intensity in the Churia region (Ghimire, 2011). Land-use change and harsh climatic conditions in Nepal's Churia region have significant consequences for both the environment and the lifestyle of the region's residents. Since the 1950s, a huge population has inhibited the Churia region. Human settlement and the different agricultural activities are generally located on the flatlands and the river valley. The slopes are more susceptible to debris flow, landslide, bank cutting, soil erosion, soil degradation along with different kinds of flood problems (Neupane and Dhakal, 2017). Thus, there is a pressing need to evaluate the land-use changes, its rate of transformation and transition, and the area victimized by the severe transformation to protect the form havocs of improper land use through formulating strategic plans and policies.

These have a great effect on the livelihood of upstream and downstream people and there are many factors which are responsible for these changes and yet it is still unclear to what extend land use and cover changes have occurred in the Churia region of Makawanpur district over the last 23 years, and how these changes are driven by the socioeconomic processes and what are the major pathways of these changes. This study is essential and rational in the context where this Churia is facing rapid land-use changes and strategies are to be formulated as soon as possible as it assembles effective technologies like GIS and remote sensing to explore the changes in land use and the sensitive area in no time. The slopes are more susceptible to debris flow,

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landslide, bank cutting, soil erosion, soil degradation along with different kinds of flood problems (Neupane and Dhakal, 2017). It is necessary to develop a strategic strategy and laws to protect the country's fragile and vulnerable highlands. Therefore, this study is crucial to monitor, assess and document the changes taken place in the past 23 years to understand the landscape dynamics along with the driving forces of these changes. The understanding of the land cover change process and driving forces will help to predict future changes and will be important to lawmakers and developers.

2. OBJECTIVES OF THE STUDY

2.1. General objective

The study's overall goal is to use RS and GIS technologies to examine the drivers and dynamics of LULC change in the Churia Region of Makawanpur District of Nepal.

2.2. Specific Objective

- To determine the temporal and geographic alterations that have occurred over the last 23 years, i.e. 1995 and 2018 using Landsat images.
- To analyze the rate of change of LULC over the different time with special focus on forest cover changes.
- To identify the causes of the transformation between forest and other land-use practices within the Churia region of the Makawanpur district of Nepal.

3. MATERIALS AND METHODS

As demonstrated in this document, the numbering for sections upper case Arabic numerals, then upper case Arabic numerals, separated by periods. Initial paragraphs after the section title are not indented. Only the initial, introductory paragraph has a drop cap.

3.1. Study area

The research field lies in the Makawanpur district of province 3 of the country Nepal. The study area is located between 27.1980 to 27.4300 North latitude and 84.6650 to 85.510 East longitude. It extends about 55.3582 to 82.8396 Km in length and 10.24 to 52.335 km in-breath and covers over 182202.31 hectares occupying 3.91 % of whole areas of the Churia range of Nepal. It shares the boundary with the Inner Terai region in the south and northern boundary with the middle mountain.

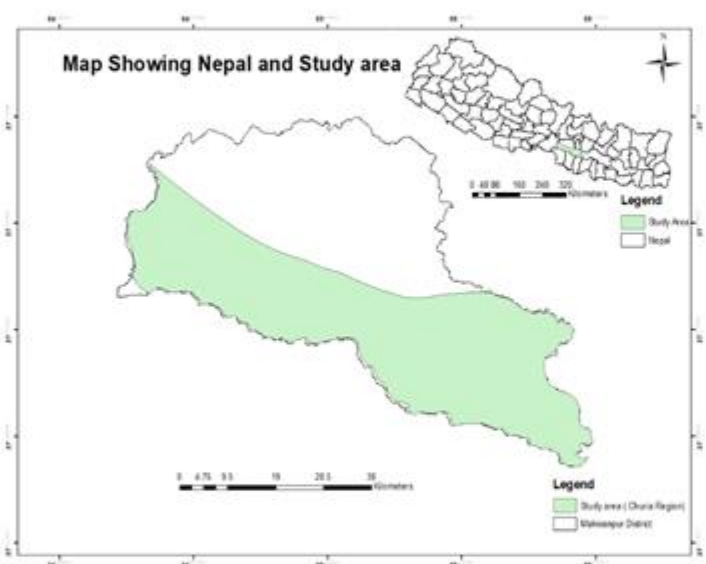

Figure 1: Map of the research field.

The total households of the study area are 61,950 with a population of 295,380 (CBS, 2011) among them, 143,875 are male and 151,505 are female. The Churia range in Makawanpur has a number of haphazard settlements, unsustainable agricultural practices in the slope lands, resulting in serious land degradation and deforestation. The research filed has winter, spring, and monsoon with a tropical climate, having average annual temperatures of 300C, but it can reach up to 390C during summer months and 50C during

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winter months. Maximum rainfall occurs during mid-June to mid-September with high intensity during mid-June to mid-July. The average annual rainfall is about 2,301mm (CBS, 2011). The study area is mainly composed of tropical and sub-tropical forest (IDEA, 2004) mostly dominated by Shorea robusta forest and tropical mixed hardwood (TMH) forest. Other forest types found in the research area are the riverine forest of Dalbergia sissoo and Acacia catechu.

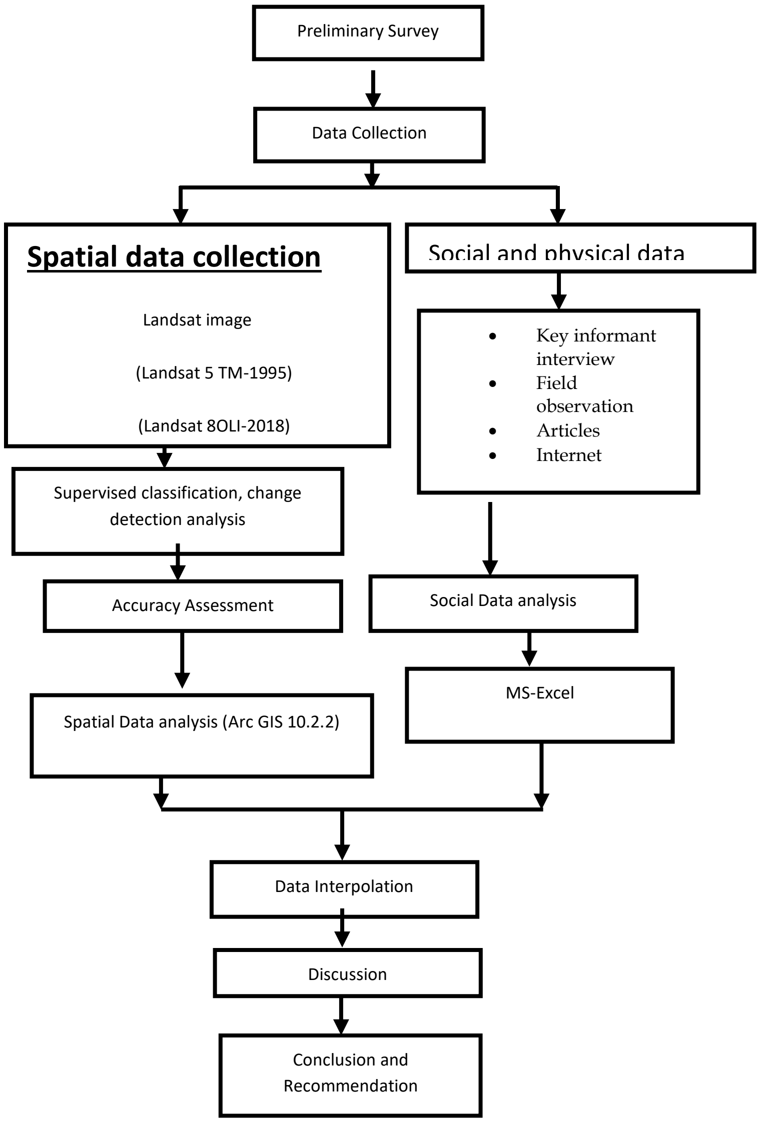

Figure 2: Flow chart of Research Design

3.2. Research Design

Figure 2 demonstrates the research design.

3.3. Data Collection

Sample Size:

According to Congalton and Green (1999) a general rule is to collect at least 50 samples per land cover class in the analysis. The appropriate amount of sample per land cover class also is adjusted according to the importance, size, and the objectives of the mapping (McCoy, 2005). It is sometimes better to increase the number of samples in the most important categories and reduce the number of the less interesting categories.

3.3.1. Primary data collection

For Spatial analysis:

Data were collected in two ways:

- Two temporal Landsat images were downloaded from the www.glovis.usgs.gov
- Data for training and validation samples of land cover classification were collected from the field using GPS.

Table 1: Landsat image used for land use/land cover classification

S. N	Satellite image	Sensor	Numbers of bands	Spatial resolution	Data of Acquired	Cloud cover (%)
1	Landsat 5	TM	1-7	30m	1995-04-30	5
2	Landsat 8	OLI/TIR	1-11	30m	2018-04-16	5

For Biophysical and social data

Preliminary Survey

Direct observation was done to observe the encroachment area, forest area, cultivated land, built-up area, sand/gravel, and water other activities related to forest and other land-use change. During the preliminary survey, an informal meeting was conducted with the key persons associated with NGOs and the local key person.

Key informant survey

To decipher the real condition of Churia range related to land use, land cover, Population pressure on Churia, drivers of LULC changes, a key informant survey was conducted by a village leader, Municipality officers, Worker, a school teacher. They were questioned about the direct temporal changes which they have been experiencing and the adaptation to those impacts. It was conducted, raising open-ended questions.

Other socioeconomic data

Data on population and population change that occurred during the periods were used from the secondary sources, i.e., data from DDC and Census data from the central bureau of statistics (CBS, 2011).

3.3.2. Secondary Data collection

Secondary data and information were collected through the Literature review, (IOF) library, documents of the Division forest office (DFO), Topo sheets from the department of the survey, journals, magazines, etc. Various websites and documents through the internet were also studied during secondary data collection and literature review.

3.4. Methods

Satellite Image Pre-processing

Two nearly clouded free satellite images were selected among the available images to assess the Land use LULC change between 1995 and 2018. Both the images are already projected into the UTM 45 zone using the WGS, 1994 datum. The radiometric correction was not performed for all the images were taken in the same season with a difference of the month.

Subset the satellite image

The research area was separated by using the subset tool of ERDAS IMAGINE.

Image enhancements

Image enhancement is generally done to improve the visibility interpretability of an image by increasing the apparent distinction between the features in the scene, digital enhancement such as edge enhancement, resolution merging.

Field Sampling Design

Training samples were collected with the help of GPS during field visits for land interpretations for the satellite image 2018. The GPS point of the training sample collection was carried out by Stratified random sampling technique and was proportional to each land use/land cover class area.

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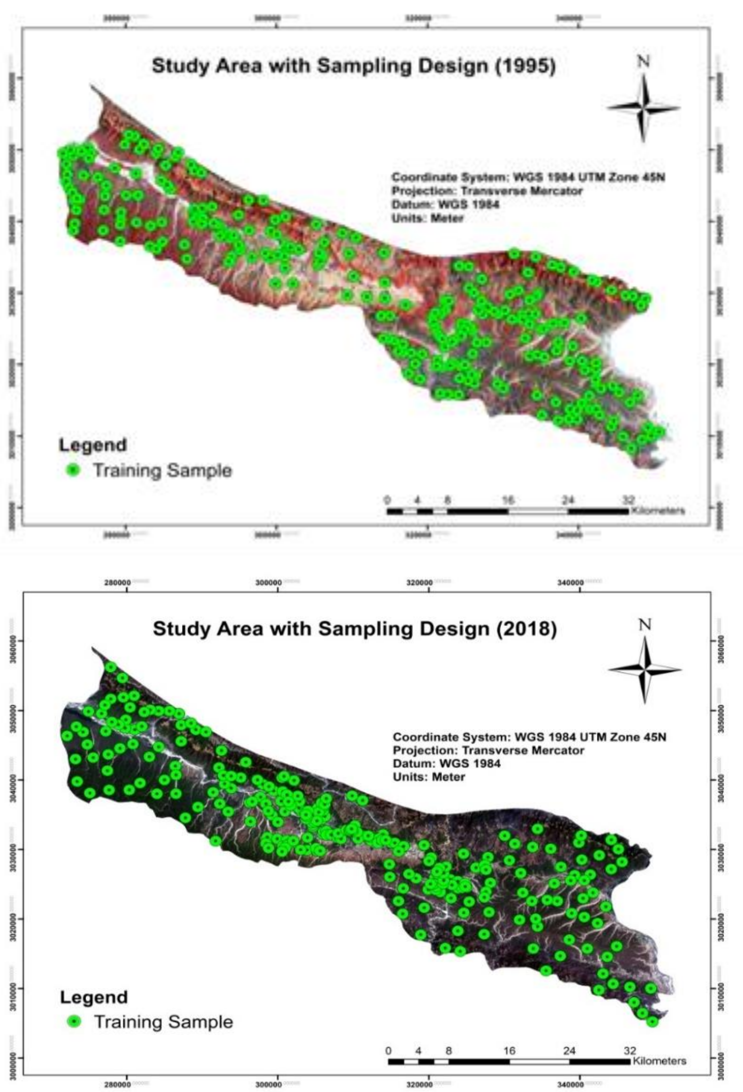

Figure 3: Image of 1995 and 2018 of Study area with sampling design.

LULC classification

Supervised classification was performed to classify the image with maximum likelihood classifier (Lille sand et al., 2004). The data of the different classification class obtained from the field survey (GPS location) was used as training samples for supervised classification of 2018 image and topographical map were used for classification of 1995 image. Land use class use for image classification were classified into the following 5 classes:

1. Forest
2. Water
3. Cultivated land
4. Sand/Gravel
5. Built-Up Area

Table 2: Description of land use land cover classes

Recorded land use/ land cover	Land use/ land cover in the field
Forest	An area covered with natural forest
Water	An area covered with rivers, lakes, etc.
Built-Up Area	An area covered by settlements, infrastructure, roadside, etc.
Cultivated land	An area covered with agricultural land, grasses, shrubs, and others
Sand/Gravel	An area covered with barren land, sandy area river bank

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- Training samples were categorized respectively to the Land classes.
- A signature file was created with the help of a training sample using GIS 10.2.2
- Supervised classification was performed on both images feeding their respective signature life
- Accuracy assessment
- Accuracy assessment of the classified images was done by calculating producer accuracy, user accuracy, overall accuracy, and overall kappa coefficient in ArcGIS 10.2.2

Change detection and analysis

The classified images prepared in ArcGIS 10.2.2 of two different dates were processed through a raster calculator to produce LULC change maps showing "From to" change in land use/ land cover between 1995 and 2018. The numerical analysis of land use dynamics was then done through Microsoft Excel.

The rate of LULC change

The following formula was used to estimate the rate of LULC change:

Rate of change (%) = $[(a_2/a_1)^{(1/n)}-1]\times 100$

(UNDP, RFDTh, and FAO, cited by Lamichhane, 2008)

Where,

a1= base year data (e.g. 1995 LULC data for different classes)

a2= end year data (e.g. 2018 LULC data for different classes)

n= no. of years (i.e., 23 years)

Identification of causes of transformation between forest and other LULC

After locating the research site, household survey, and direct field observation were done for the identification of causes of transformation.

Data Analysis

- Spatial data were analyzed by using Arc GIS 10.2.2
- Social data were analyzed by using Ms-excel.

4. RESULT AND DISCUSSION

4.1. Result

4.1.1. LULC in 1995

Five LULC classes were classified in this period. The land-use patterns included forest, cultivated land, built-up area, sand/gravel, and water (Figure 4). Forest land covered 99254.19 ha which was 71.82 % of the total area. Cultivated land covered 24891.66 ha which was 18.01 % of the total area. Built-up area covered 4938.76 ha which was 3.75% of the total area. Sand/gravel-covered 7662.86 ha which was 5.54% of the total area. Water bodies covered 1452.05 ha which was 1.05 % of the total area given in (Table 4).

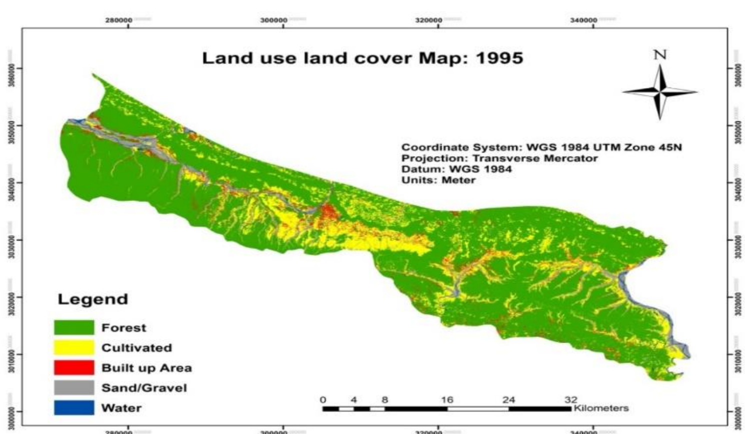

Figure 4: Land use Land cover map of 1995.

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4.1.2. LULC in 2018

Similarly, five Land use land cover classes were classified in this period. The land-use patterns included forest, cultivated land, built-up area, sand/gravel, and water (Figure 5). Forest land covered 89,449.49 ha which was 64.73% of the total area. Cultivated land covered 22,098.06 ha which was 15.99% of the total area. Built-up area covered 14,859.69 ha which was 10.75% of the total area. Sand/gravel-covered 10,989.59 ha which was 7.95% of the total area. Water bodies covered 801.25 ha which was 0.58 % of the total area (Table 3).

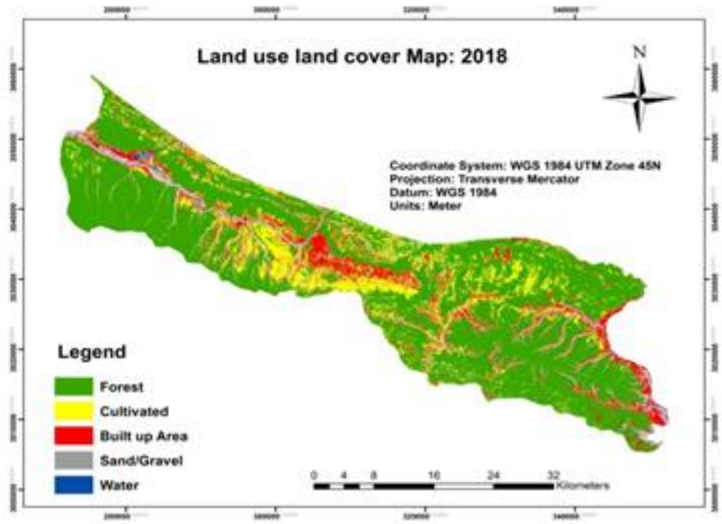

Figure 5: Land use Land cover map of 2018.

Table 3: Status of Land use Land cover in 1995 and 2018

Land use Land cover types	1995		2018	
	Area (ha)	% cover	Area (ha)	% cover
Forest	99254.19	71.82	89449.49	64.73
Cultivated land	24891.66	18.01	22098.06	15.99
Built up area	4938.76	3.57	14859.69	10.75
Sand/Gravel	7662.86	5.54	10989.59	7.95
Water	1452.05	1.05	801.25	0.58
Total	138199.51	100	138198.08	100

4.1.3. Accuracy assessment of the image classification

The confusion matrix presents the overall classification accuracy of two classified maps of 1995 and 2018. ArcGIS 10.2.2 was used to calculate the accuracy of the classified image. The accuracy report is presented below. The overall accuracy of the classification was 82.5% for 1995 image classifications and 86.11% for 2018 classification.

Table 4: Accuracy Assessment for 1995.

	Land use land cover classes	Reference Data						Producer accuracy
		Forest	Cultivated land	Built-up Area	Sand/Gravel	Water	Grand total	
Classified Data	Forest	59	4	2	1	0	66	89.39
	Cultivated land	2	47	8	0	0	57	82.46
	Built up Area	1	5	28	3	0	37	75.68
	Sand/Gravel	0	2	2	25	1	30	83.33
	Water	1	2	1	2	16	22	72.73
	Grand Total	63	60	41	31	17	212	

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	User's accuracy	93.65	78.33	68.29	80.645161	94.12		
	Overall accuracy = 82.5% Kappa statistics = 0.7729							

Table 5: Accuracy Assessment for 2018.

	Land use land cover classes	Reference Data						Producer accuracy
		Forest	Cultivated land	Built-up Area	Sand/Gravel	Water	Total	
Classified Data	Forest	65	4	2	1	0	72	90.28
	Cultivated land	3	59	6	0	0	68	86.76
	Built up Area	2	5	37	2	0	46	80.43
	Sand/Gravel	1	2	1	33	2	39	84.62
	Water	0	1	1	2	23	27	85.19
	Grand Total	71	71	47	38	25	252	
	User's accuracy	91.55	83.10	78.72	86.84	92.00		
	Overall accuracy = 86.11% Kappa statistics = 0.8209							

4.1.4. LULC change

	Land use Land cover Classes	2018					
		Built Up area	Cultivated Land	Forest	Sand/Gravel	Water	Grand Total (1995)
1995	Built up Area	1912.72	1141.98	1348.05	512.73	23.27	4938.76
	Cultivated	6943.74	11943.93	2757.97	3132.89	112.44	24891.66
	Forest	3844.25	8138.80	85112.44	2070.68	89.54	99254.19
	Sand/Gravel	1893.30	726.16	193.47	4474.32	375.60	7662.86
	Water	265.27	147.18	37.56	798.05	201.78	1452.05
	Grand Total (2018)	14859.28	22098.06	89449.49	10988.67	802.62	138199.51

The land use land cover change in 1995 and 2018 was compared in (table 6). There was a fluctuation between total areas of different land use, land cover classes between 1995 and 2018. Forest area was decreased by 7.09%; cultivated land was decreased by 2.02%, whereas sand/gravel area increased by 2.41%, the built-up area increased by 7.18%, and water bodies were decreased by 0.47% by 2018. (Table 6) shows the alteration in the major land use Land cover types within the Churia region of Makawanpur district.

Table 6: LULC change in 1995 and 2018

Land use Land cover types	1995		2018		Change	
	Area (ha)	% cover	Area (ha)	% cover	Area (ha)	% cover
Forest	99254.19	71.82	89449.49	64.73	-9804.70	-7.09
Cultivated land	24891.66	18.01	22098.06	15.99	-2793.60	-2.02
Built up Area	4938.76	3.57	14859.69	10.75	9920.93	7.18
Sand/Gravel	7662.86	5.54	10989.59	7.95	3326.74	2.41
Water	1452.05	1.05	801.25	0.58	-650.80	-0.47

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Total	138199.51	100	138198.08	100		

4.1.5. Trend analysis of LULC changes in 1995 and 2018

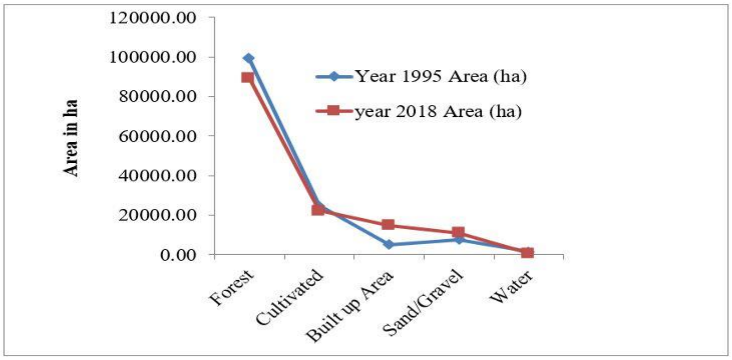

Figure 6: Trend analysis of LULC in 1995 and 2018.

4.1.6. Land use Land cover dynamics

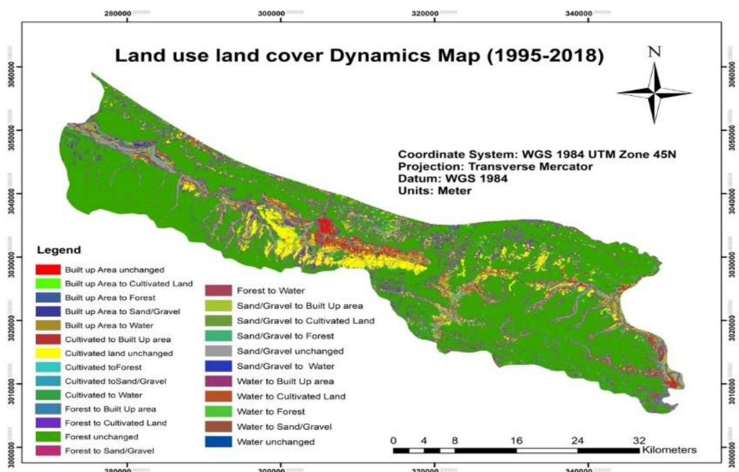

Figure 7: LULC dynamics in 1995 and 2018.

4.1.7. Area transformation from 1995 to 2018

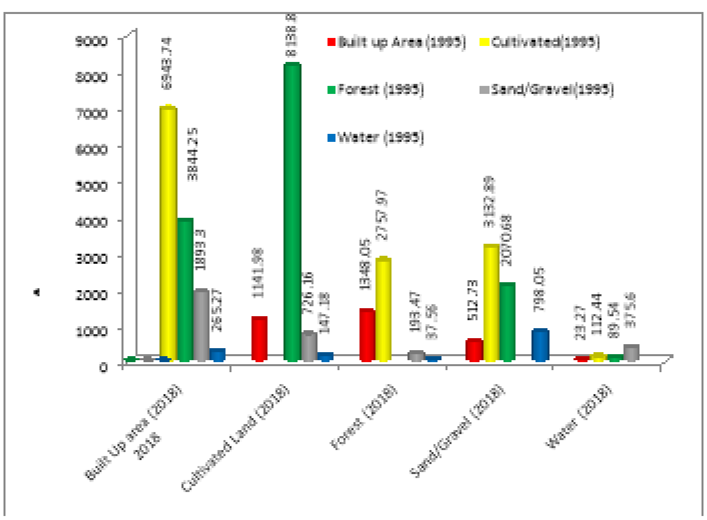

Figure 8: From to change comparison.

The research reveals that a considerable amount of forest, i.e., 14,143.27 ha of forest was converted into the other LULC classes

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from 1995 to 2018. However, 4,337.05 ha of other LULC classes transformed into the forest, but not enough to balance the decreased rate. Similarly, a huge amount of cultivated land, i.e., 12,947.04 ha was converted to other classes while 10,154.13 ha of land classes converted to cultivated land. In the same way 12,946.56 ha of other land cover classes converted to build up area while 3,026.03 ha of built-up area was transformed into other land classes and 6,514.35 ha of other land classes converted to sand/gravel while 3188.53 ha of sand/gravel converted to other land classes and 600.84 ha land classes to water while 1,248.06 ha of water converted to other land classes. Finally resulting and decreased of 9,804.70 ha of forest and increment of 9,920.93 ha of built-up area and decreased of 2,793.60 ha of cultivated land, 650.80 ha of water with an increment of 3,326.74 ha of sand/gravel.

The research also shows that the largest transformation between classes was the conversion of 8,138.80 ha of forest to cultivated land followed by conversion of 6,943.74 ha of cultivated to build up the area. However, the smallest transformation was the conversion of 23.27 ha of built-up area to water. Likewise, small area of sand/gravel in the forest. Conversion of forest to cultivated land, sand/gravel to build up area indicates the possibility of encroachment by people. The map shows the major conversion of cultivated land to sand/gravel along the river bank region due to the flooding and riverbank cutting.

4.1.8. Rate of LULC change

The following figure shows that the built-up area has the highest rate of change or fluctuation in the area, i.e., 4.91%, followed by water (-2.55%), sand/gravel (1.58%), cultivated land (-0.52%), and forest (-0.45%) respectively. We can conclude from this result that; the forest is decreasing by 0.45% every year and if this rate of forest degradation is not controlled the condition of Churia will be worse after 23 years than today. If the trend of built-up area expansion remains the same the open space is the cultivated land that is remaining in the Churia region of Makawanpur district will be covered by built-up area soon.

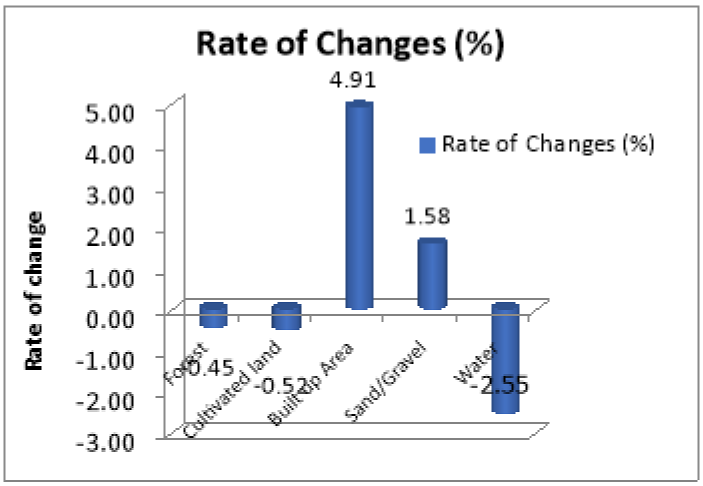

Figure 9: Rate of LULC change

4.1.9. Drivers of LULC change

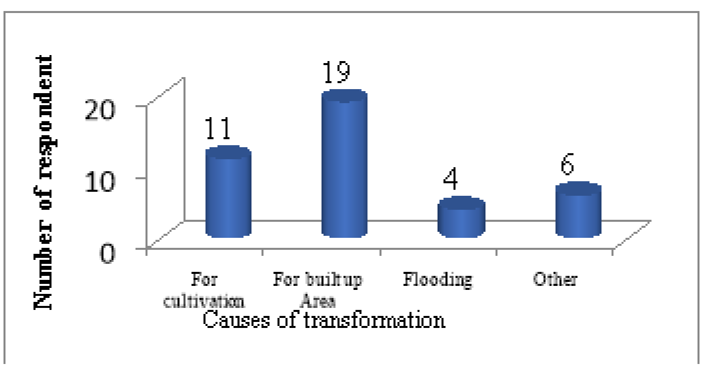

Figure 10: Causes of transformation.

The majority of the respondents (83%) claimed that the LULC of the Churia region of Makawanpur district is changing and a few of them (17%) of the respondents did not have any ideas about it.

The result showed that 47.5% of respondent believed that human settlement expansion and infrastructure development had led

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to the change in land use, 27.5% of respondent believed that cultivated land expansion had led to the change in land use Land cover, 15% believed that other activities like riverbank cutting, mining had led to the change in land use land cover and 1% believed that flooding and soil erosion had led to the land use land cover.

4.1.10. Cause of forest cover decrease

Based upon the household and key informant survey, most of the people in the area believe that the forest cover decreased due in cost of cultivated land, some of them believe that forest cover change due to the infrastructure development, and few of them believe it is due to riverbank cutting.

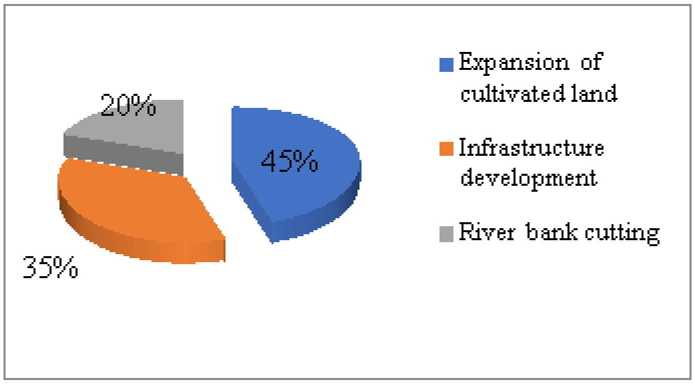

Figure 11: Cause of forest cover decrease.

5. DISCUSSION

Over the 15 years from 1995 to 2010, the area of forest cover was found to be decreased in 27 districts (Churia Assessment report 2014). Among them, Makawanpur district is one of them, the forest coverage of Churia region Makawanpur district was 89,996 ha and the rate of decrease in forest cover was (-0.24%), (Churia assessment report, 2014). This study shows that the forest coverage in 2018 is 89,449.94 ha i.e., the rate of decrease in forest cover is (-0.45%). Hence the rate of forest degradation is increasing and the rate of LULC change is also increasing. Forest cover is transforming to cultivated land and cultivated land is transforming to build up area. The forest cover is decreasing rapidly in the past 23 years. The built-up area and sand/gravel are increasing rapidly, it shows that the uncontrolled expansion of human settlement and riverbank cutting is increasing in the Churia region of Makawanpur district. Loss of cultivated land and forest land due to encroachment, changing river morphology, landslide, and soil erosion have been natural drivers of change landscape in the Churia region. Human settlement expansion, out-migration, infrastructure development, demographic changes, climate change, and policy are the major driving forces for the change in LULC.

6. CONCLUSION

The study reveals that the Churia region of Makawanpur district has gone through considerable changes in LULC during the study period. The research finding shows that the decrease in the forest cover at a rate of 0.45%, cultivated land at a rate of 0.52%, water at a rate of 2.55% and with a concomitant increase of built-up area at a rate of 4.91 %, and sand/gravel at a rate of 1.58% respectively. The transition matrix reveals that the largest transformation between LULC was the conversion of forest to cultivated land (8,138.80 ha) followed by the conversion of cultivated to build up an area (6,943.74 ha). The considerable area of water has turned to sand/gravel (798.05 ha). During the period of 23 years (1995-2018), land use of the Churia region of Makawanpur district was found to decrease in forest cover by 7.09%, but an increase of 7.18% in the built-up area, whereas sand area changes to water bodies due to the river bank cutting and flooding. It shows that the cultivated land of the Churia region of Makawanpur district is transformed into a built-up area. The increase of cultivated land and human settlement, infrastructure development, riverbank cutting, and flood were found to be causal drivers for dynamics in the Churia region.

Conflict of interest

The Authors have no conflicts of interest that are directly relevant to the content of this clinic-pathological case

Financial Resources

There are no financial resources to fund this study.

Data and materials availability

All data associated with this study are present in the paper.

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ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS